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# World War II Technology that Changed Warfare - Radar and Bombsights

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# World War II Technology that Changed Aviation Warfare



## Radar and Bombsights



<http://steveblank.files.wordpress.com/2009/04/wurzburg-reise-radar.jpg>



[http://farm2.static.flickr.com/1246/4728554459\\_97034bb3a9\\_z.jpg](http://farm2.static.flickr.com/1246/4728554459_97034bb3a9_z.jpg)

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SCI3050 Science & Civilization  
Final Project

# Introduction

Two pieces of technology that stand out in the aviation history of World War II are Radar and Bombsights. Both technologies played a crucial role in the defensive and offensive strategies of all the countries involved.

During World War II Radio Detecting and Ranging or RADAR, saw its first use in combat operations. (“Early”) Although radar came of age during the war (Goebel) it is often referred to as the weapon that won the war and the invention that changed the world! (“Radar”)

Radar was a technology that allowed land bases to detect incoming aircraft and direct their anti-air defenses in the direction of the incoming aircraft. Radar was also used in an offensive strategy by giving aircraft the ability to attack targets at night and during inclement weather. (“World”)

Although the use of aircraft in combat wasn’t a new concept in World War II, the development of the bombsight helped to make them a strategic weapon.

Bombsight technology allowed for more accurate bombing runs and precision targeting of military and industrial locations. By factoring in altitude, air speed, and ground speed, World War II bombsights allowed bombers to fly at higher altitudes during their bombing missions which provided safety to the bombers and their crews from anti-aircraft guns and defending fighter aircraft. (Searle)



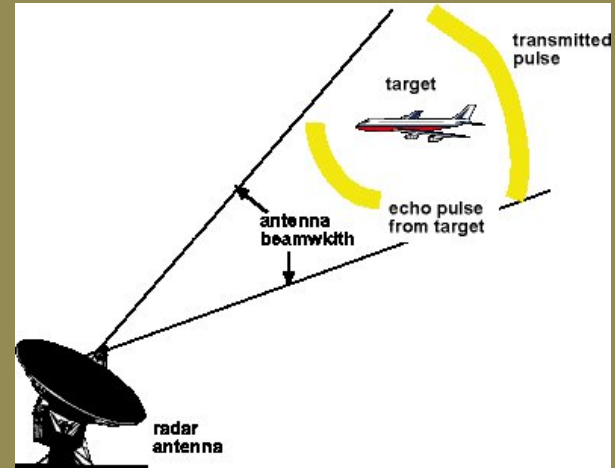
# What is Radar?

**Radar (radio detecting and ranging) is used to detect distant objects by receiving radio waves that are reflected from the object.**

Radar technology works by transmitting strong, short pulses of radio energy into the air in a specific direction using what is called a directional antenna. When these pulses hit an object like a ship, or aircraft they bounce off the object and back to the antenna. These signals are then converted into an electric signal and shown on screen where they can be viewed by an operator. (“World”)



<http://chasewilliston.wordpress.com/>



<http://chasewilliston.wordpress.com/>

The position of a detected target is determined by measuring the time it takes the signal pulse to travel to the target, bounce off, and return to the transmitting antenna. Combining this with the direction the antenna is pointing, gives the targets position. (“World”)

Since radar is conducted with radio waves, it is effective day or night and in all weather con'ditions. (“World”)

Today, radar is used for many purposes such as navigation, targeting, air traffic control, and weather tracking. (“Radar”)

# Chronology of the Beginnings of Radar

Before WWII, there were many people around the world experimenting with radio waves and how to use them to detect objects. Many of these experiments fell into obscurity or did not obtain any customer interest.

1904, Christian Hülsmeyer received a German patent for the *Telemobiloskop*, or Remote Object Viewing Device. Intended for use to prevent ship collisions, the device achieved ranges of 3000m against ships. (“The History”)

1925/26, American physicians and British researchers perform measurements of the Earth's ionosphere using a pulsed radio transmitter which could be described as a radar. (“The History”)

1934, researchers at the Naval Research Laboratory in Washington, D.C., began work on bouncing radio signals off of objects after noticing that ships traveling down the Potomac River interfered with radio signals being transmitted across the river. (“Radar”)

1935, a French ship was equipped with a collision avoidance device of local fabrication and in 1936 A land-based device, the *barrage electronique* was tested was used in the early days of WWII. (“The History”)

1935, Sir Robert Watson-Watt, who is considered one of the early pioneers in radar, successfully detected an aircraft with a radio device. This prompted full scale development of a radar system and was the starting point for the world's first radar network called Chain Home (CH), which became operational in 1937. (“The History”)

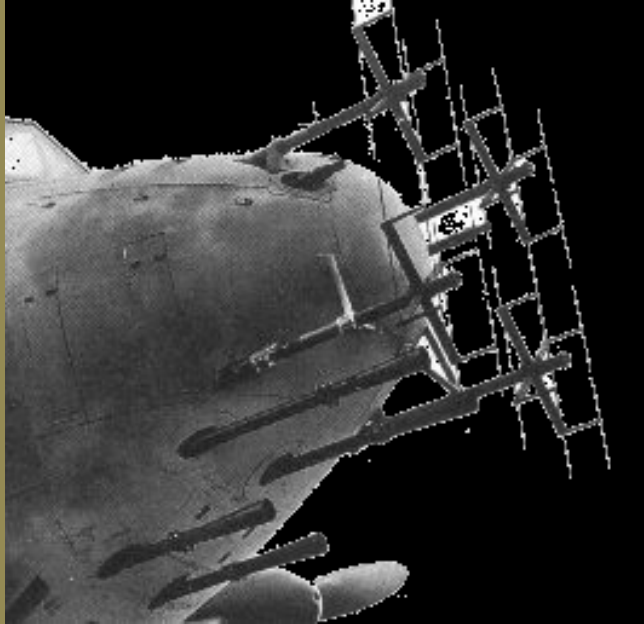
By 1939, Britain, Germany, France, Hungary, Italy, the United States, Japan, the Netherlands, Russia, and Switzerland all had operational radars.



# Radar Technology

**Military radar is classified into two types, detection and fire control.**

Detection Radar is used to create an electronic map of all objects in all directions and at as great a distance away as possible. The purpose of this type of radar is mainly for early warning detection against aircraft and ships, ground controlled intercept of aircraft (done by directing fighter aircraft to detected incoming aircraft), and for mapping ground terrain for navigation and targeting by bombers. (“World”)



<http://www.century-of-flight.net/Aviation%20history/WW2/radar%20in%20world%20war%20two.htm>



<http://www.loc.gov/rr/scitech/trs/trsorsd.html>

Fire Control Radar is used mostly by night fighters to locate the precise position of a previously detected target. This enables the guns to be aimed at, and hit the target without actually seeing the target. This type of radar is also used to guide pilots close enough to a target to see it, aim their guns and hit it. (“World”)

This was a great advantage for pilots because It gave them the opportunity to attack a target at night with relative accuracy and be able to depart the area without detection, providing the target didn't have Detection Radar!

# Types of Detection Radar

The British Chain Home (CH) system was a network of early warning radars used to defend Britain during the Battle Of Britain. With a range of 185 miles, this early and primitive radar allowed the British Fighter Command to optimally engage incoming German bomber formations. (“World”)

The first workable unit was put into service in 1935 and by 1937 the system was detecting aircraft at a range of 100 miles. (“The British”)

A typical CH site was made up of 3 – 4 transmitter towers that were 350 ft. tall and space about 180 ft. apart and could be tuned to 4 different wave length bands. (“The British”)

A major problem with the Chain Home system though was that it would detect ghost or false images which was caused by it radar pulse bouncing off of distant object and being picked up by the next radar pulse being emitted. (“The British”)



<http://www.century-of-flight.net/Aviation%20history/WW2/radar%20in%20world%20war%20two.htm>



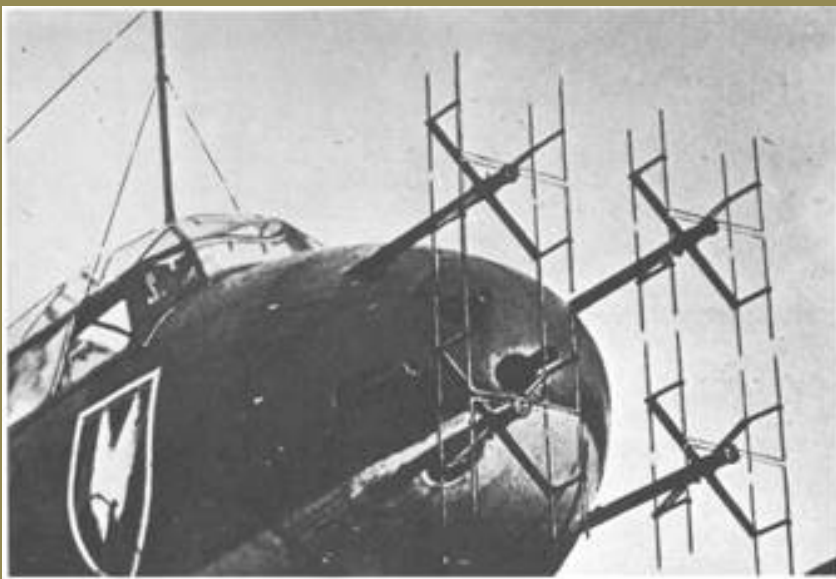
The German Würzburg GCI (ground controlled intercept) Radar entered service in 1940.

With a range of 18 miles, the Würzburg was used to direct fighters, particularly night fighters, close enough to enemy bombers to then independently intercept them. (“World”)

<http://www.century-of-flight.net/Aviation%20history/WW2/radar%20in%20world%20war%20two.htm>

# Types of Fire Control Radar

**Most Fire Control Radars were mainly used on Naval ships to direct their guns during shore bombardments, although Germany did develop an aircraft mounted radar to be used in target acquisition.**



<http://www.century-of-flight.net/Aviation%20history/WW2/radar%20in%20world%20war%20two.htm>

**The German Lichtenstein SN2 had a range of 2.5 miles ("World") and was mounted onto the front of night fighters like the JU88 (left) and the ME110G-4 (below)**



[http://www.century-of-flight.freeola.com/Aviation%20history/WW2/german\\_radar.htm](http://www.century-of-flight.freeola.com/Aviation%20history/WW2/german_radar.htm)



# Radars Chance to Change History

**The use of radar almost prevented the attack on Pearl Harbor in 1941 !**

The attack on Pearl Harbor in 1941 could have been avoided because of the active use of radar. On the morning of December 7<sup>th</sup>, almost an hour before the first Japanese plane attacked, a mobile radar stationed on the north side of Oahu detected the approach of the Japanese aircraft.

The operators reported the sighting to their superiors but their report was dismissed because the operators were thought to be inexperienced. ("The History")

Had the reports made by the radar operators been acted upon the Japanese attack on Pearl Harbor could have been completely averted. The history of World War II as we know it would have been entirely different.

This photo shows what is believed to be the actual SCR-270-B radar, at its station on the island of Oahu, that picked up the advancing Japanese air force.

The SCR-270-B had a scanning range of 140 miles, with a frequency pulse of 621 hz and ran at 100 kw of power.

From 1939-1944, 794 of these radar units were produced. There were actually 5 set up and in operation on Oahu the morning of the Japanese attack on Dec. 7 1941 (Budge)



# Effectiveness of Radar

As stated in the previous slide, the use of radar could have changed history for the U.S. as it discovered the advancement of the Japanese air force. What ultimately turned the attack into a surprise one was the inability to take the radar report seriously.

Britain's use of radar allowed them to defend against German air attacks because they knew where the majority of the German air force was heading. Although Germany still inflicted major damage during their air raids, without the forewarning from radar, the damage that Britain experienced could have been dramatically more wide spread. ("Radar")

Until the implementation of radar navigation and fire control radar most bombing that was conducted was indiscriminate and usually done as "area" bombing (placing large quantities of bombs on one area). Having the ability to "precision" bomb allowed for more accurate destruction of military targets and industrial areas and less loss of civilian life. ("The Bombing")

One important benefit for the Allies concerning radar was their advancement in the technology over the Germans. With the leadership in Germany having a stronger preference for offensive weapon systems than defensive ones, the Allies were able to defend against German attacks as well as strike more precisely against German targets, weakening their war supporting industry. (Colon)



[http://www.century-of-flight.freeola.com/Aviation%20history/WW2/german\\_radar.htm](http://www.century-of-flight.freeola.com/Aviation%20history/WW2/german_radar.htm)

# Bombsights

**A bombsight is a device used by aircraft to sight a target from the air and then accurately drop a bomb/s on that target**

There are several factors that must be accounted for in order to properly place a bomb on a target.

When a bomb is dropped from an airplane it does not fall straight down but actually moves forward as it falls. This is caused by the horizontal movement of the plane in flight . (“The Principles”)

A falling bomb is also affected by the air resistance created by falling through the air, which causes the bomb to always be behind the plane when it strikes the target. (“The Principles”)



[http://commons.wikimedia.org/wiki/File:Boeing\\_B-17G\\_2\\_BG\\_dropping\\_bombs.jpg](http://commons.wikimedia.org/wiki/File:Boeing_B-17G_2_BG_dropping_bombs.jpg)

The aircraft must be flying in a vertical plane passing through the target at the time of bomb release and also flying on an even keel. Bombing during World War II was virtually always done when flying either up or down wind. (“The Principles”)

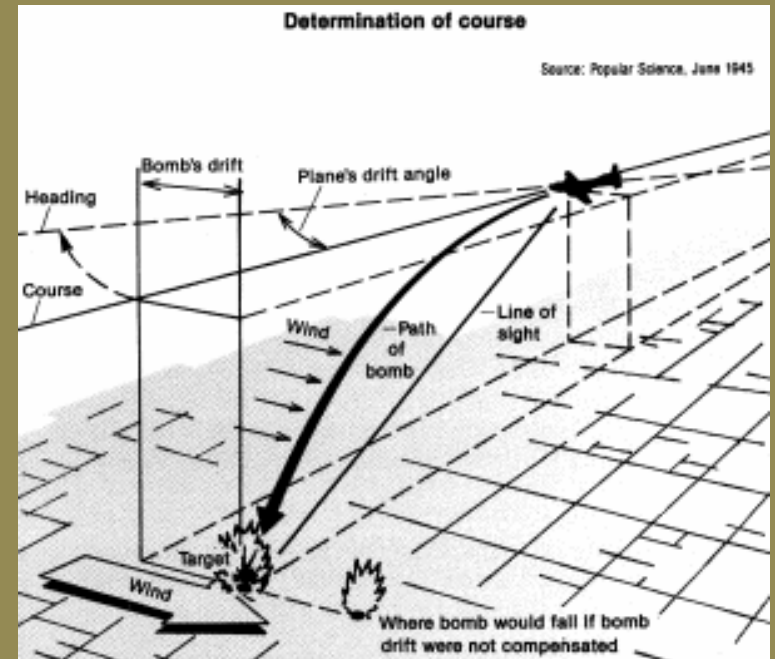
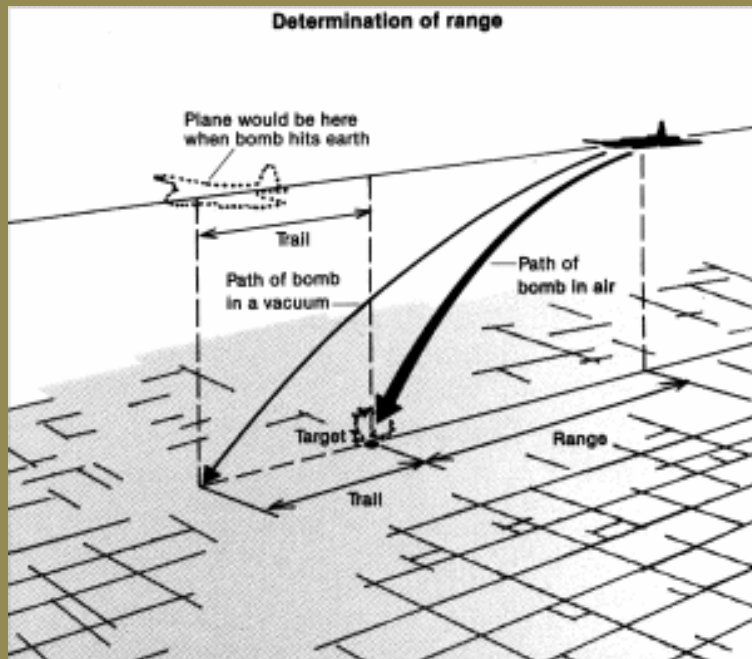
# What a Bombsight Does

A bombsight determines , in real time , both the range and the course of the plane so as to calculate the proper moment for releasing a bomb.

The sight must also compensate for air resistance, which will cause the bomb to trail behind the plane (left image), and cross winds, which will make it drift downwind to the side of the plane's path (right image).

Other factors that contribute to where a bomb lands included the bombs ballistics and the target's altitude, which affects, the time it takes the bomb to fall. (Searle)

Proper aiming angle for a bomb drop is made when a bombsight is adjusted to compensate for the aircrafts altitude, air speed, and its speed relative to the ground. (“The Principles”)





# Pre-World War II Bombing

Before the invention of mechanical bombsights, bombing was done manually with the bombardier physically dropping a bomb with his hands.

This type of bombing was obviously very indiscriminate and produced more of a psychological effect on the enemy than a physical one.



<http://www.corbisimages.com/Enlargement/NA007595.html>

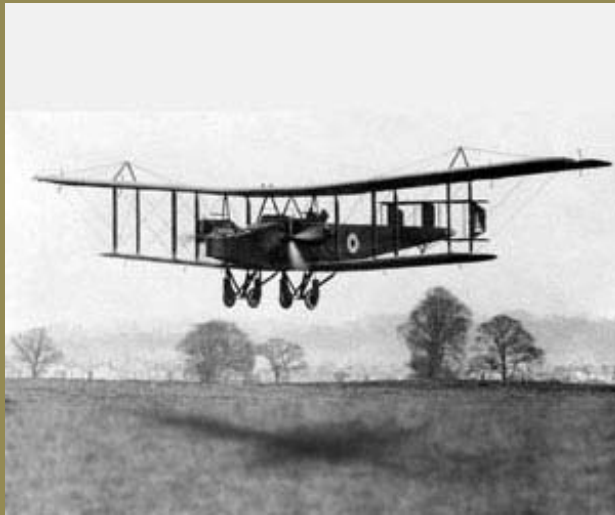


<http://images.google.com/hosted/life/?imgurl=0f76a87f37fbc1ee&q=wwi%20bombers&prev=/images%3Fq%3Dwwi%20bombers%26hl%3Den%26client%3Dfirefox-a%26sa%3DG%26rls%3Dorg.mozilla:en-US:official%26biw%3D1440%26bih%3D719%26gbv%3D2%26tbs%3Disch:11,6134>



# Pre-World War II Bombsights

Early forms of bombsights were just viewing scopes with crosshairs to aim by. As the technology in bombsights advanced, the sights could compensate for the ballistic trajectory of the dropping ordnance by correcting for altitude, airspeed heading of the aircraft, wind speed and the aerodynamic properties of the particular bomb being dropped. ("Bombsight")



[http://www.militaryfactory.com/aircraft/detail.asp?aircraft\\_id=454](http://www.militaryfactory.com/aircraft/detail.asp?aircraft_id=454)

With the capability to process aerial information like aircraft altitude, speed, wind velocity and drift, the MK 1A was an improvement to an aircrafts bombing capabilities. During World War I, this sight was widely used with 11 operational RAF squadrons. ("Handley")



<http://reference.findtarget.com/search/Bombsight/>

The Drift Sight MK 1A was the first bombsight used during wartime.

It was developed by the British and used on the Handley Page O/400 (pictured at left) heavy bomber during World War I. ("Bombsight")

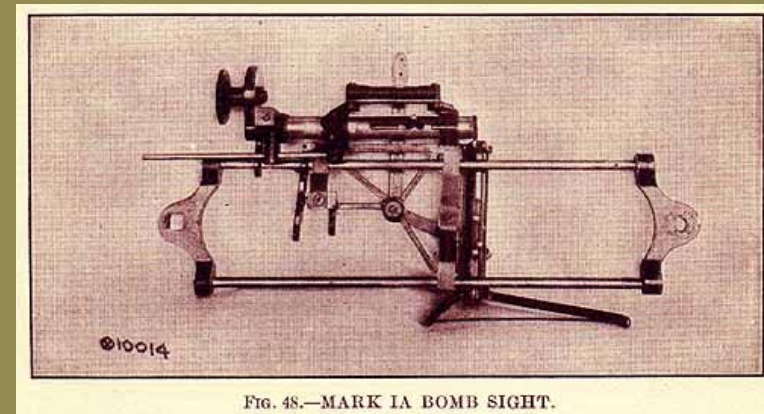


FIG. 48.—MARK 1A BOMB SIGHT.

<http://www.repligun.com/HDBKACArm/BombSightMk1A.html>

# The Advancement of Bombsights



<http://www.century-of-flight.net/Aviation%20history/WW2/bombing%20raids.htm>

Accurate high altitude bombing was relatively impossible before the development of bombsights. To bomb accurately, planes had to fly at lower altitudes, placing themselves within the range of anti-aircraft guns. Britain overcame this issue by flying their bombing runs at night. This created another issue though, indiscriminate bombing. The U.S. disliked this form of bombing as it resulted in civilian casualties. (“The Bombing”)

The U.S. implemented the use of two bombsights, the Sperry Bombsight, and the Norden Bombsight. Both of these sights allowed for precision bombing raids during the day which increased the safety of the aircraft, the crews, and raised the effectiveness of the bombs by hitting important targets with minimal damage to civilians and surrounding areas. (“The Bombing”)

A Norden Bombsight in the bombardiers bubble  
of a B-17 Flying Fortress



[http://upload.wikimedia.org/wikipedia/commons/3/3a/Norden\\_Bomb\\_Sight\\_B17G.jpg](http://upload.wikimedia.org/wikipedia/commons/3/3a/Norden_Bomb_Sight_B17G.jpg)

# The Sperry Bombsight

The Sperry bombsight was developed by the Sperry Gyroscope Co. and a modified Sperry O-1 bombsight was first used in combat in 1941 by a British bomber.

During the war the Sperry S-1 was used by the U.S. 15<sup>th</sup> Air Force and the British Royal Air Force on B-24 bombers.

The Sperry bombsight had controls on both sides which allowed range and course to be adjusted simultaneously. It was mounted on shock absorbers to help prevent shaking the telescope optics caused by the vibration from the planes engines.

The Sperry S-1 bombsight was electrically connected to another Sperry invention, the A-5 Autopilot. This system allowed the pilot to turn over the aircraft to the bombardier once the bombing run had started. The bombardier would fly the aircraft by tracking the target through the bombsight. Once the sight determined that the target had been reached, it alerted the bombardier and then dropped the bomb/s.

The combination of these two technologies developed by the Sperry Gyroscope Co. led to unprecedented accuracy in bombing during World War II.

(Searle)



# The Norden Bombsight

Designed by Carl Norden, a previous employee of the Sperry Gyroscope Co. , the Norden Bombsight was used in conjunction with the aircrafts automatic pilot , another Norden development known as Stabilized Bomb Approach Equipment.

Providing an accurate ground speed was one of the sources of improved accuracy the Norden bombsight provided compared to contemporary instruments.

The Norden was operated by pointing the telescope out in front of the aircraft in order to acquire the target while still approaching it. Once a target was acquired, the motors in the sight head would keep the telescope pointed directly at the selected target, as the aircraft approached it.

When the aircraft was on its final approach to a target the bombardier selected the primary target in the sight, turned on the autopilot and took control of the aircraft. From that point on, the bombsight actually flew the aircraft, attempting to keep it on the chosen path and correcting for any last-minute adjustments provided by the bombardier. At the proper moment it automatically dropped the bombs.

The Norden bombsight was used by the U.S. Army and Navy during World War II, and stayed in service up until the Vietnam war.

(“Norden”)





# The German Lotfe 7

Another widely used bombsight in World War II was the German Lotfernrohr 7 (Lotfe 7) bombsight, which became the primary bombsight in most of the Luftwaffe level bombers.



<http://reference.findtarget.com/search/Norden%20bombsight>

The German Lotfe 7 was very similar to the Norden Bombsight because it was a direct rip-off of the Norden. In 1938, Herman W. Lang, an employee of the Norden Corporation and also a German spy, flew to Germany and reconstructed the plans for the Norden bombsight from memory for the German military authorities. ("Lotfernrohr 7")

Although the Lotfe 7 functioned pretty much the same way as the Norden, it did have some advantages:

- It was much simpler to operate and maintain with the whole mechanism being contained in one unit.
- It could view targets directly in front of the aircraft, so the bombardier could use the real target for adjustments, where the Norden had to be "tuned" on a test target located closer to the aircraft.
- Unlike other bombsights that could only be used vertically, the Lotfe 7 could be used against targets 90° to 40° in front of the aircraft, and up to 20° on either side.

("Lotfernrohr 7")



<http://battlegroundrelics.com/relics/lotfe-7d-1-luftwaffe-bombsight>



# Effectiveness of Bombsights

**Did the use of bombsights during World War II positively effect bombing?**

It is nearly impossible to differentiate between the effects of the strategic bombing campaign and the area bombing campaign that took place in Europe. Even when modern bombsights were used during a bombing run, there were usually so many aircraft involved that the result became more of an area bombing than a strategic one. In 1944, 900 B-17 bombers attacked Berlin resulting in approximately 25,000 civilian deaths. ("World War II") Although there was probably some damage done to military targets, can 25,000 civilian deaths be considered strategically effective?



<http://www.historylink101.com/ww2-planes/aa-b-17-bomber-1.htm>



<http://www.life.com/image/50648375>

Postwar evaluation has shown that precision high-altitude bombing was much less effective than believed. Even though the bombsights worked, the generally poor weather conditions over Europe interfered with their success. (Searle) Even under perfect conditions only about 50 percent of allied bombs fell within a quarter of a mile of the target, and American flyers estimated that as many as 90 percent of bombs would miss their targets. ("Norden")

It can be argued over whether the military commands even cared about precision bombing as a strategy to win the war!

Prime Minister Winston Churchill ordered in 1940 -  
“an absolutely devastating, exterminating attack  
by very heavy bombers upon the Nazi homeland.”  
 (“The Bombing”)

Air Vice Marshall Harris added to this by stating –  
“We shall destroy Germany’s will to fight...render  
25 million Germans homeless, kill 900,000...”.  
 (“The Bombing”)

Adolph Hitler stated that same year -  
“We will raze their cities to the ground....”  
 (“The Bombing”)



<http://www.century-of-flight.net/Aviation%20history/WW2/bombing%20raids.htm>



<http://www.life.com/image/50650839>

Although the U.S. military command says it preferred to conduct precision bombing as apposed to area bombing to help lessen the amount of civilian casualties, it is difficult to determine if the use of bombsights helped to achieve this goal. A good part of the “precision” that went into the precision bombing is probably due to the skill of the bombardiers and pilots that flew the missions.

# Conclusion

The development and advancement of technology can take a bizarre path through the history of civilization. A technology that was developed for war has evolved into something that is taken for granted in peace time. Radar was developed as a means to track incoming enemy aircraft and find ground targets to bomb. It is now used to monitor commercial air traffic, track weather patterns, and aid in general navigation.

Radar probably saved tens of thousands of lives during World War II and now it is used to provide basic comforts to society like telling us when it is going to rain or snow next!

Although there are no strong numbers to prove whether bombsights produced more strategic bombing effects than “area” bombing did, the bombsight helped push the military mind set to develop more accurate means of bombing. The concept of guided bombs, smart bombs, and computer target acquisition can be accredited to the concept of bombsight technology. These modern technologies are designed to find a specific target and destroy it with precision, much as the idea of strategic bombing with early bombsights was meant to. Also, the bombsights in World War II were implemented to help keep aircraft and crews safer by allowing them to bomb from higher altitudes. Modern guided and smart bombs provide a similar safety through their technology of “finding” a target, instead of just being dropped on one.

The general concept of a Bombsight has also been used for non combat means such as in the machining industry. Many milling and engraving machines use a bombsight (actually referred to as a center scope or site scope) for aligning tools to a specific milling/drilling point on a substrate.

Much can be said about the development of radar and bombsights during World War II concerning their operational effectiveness and whether or not they helped either side win or lose the war. One thing is for certain though, both of these war tools not only changed how wars were fought, but how civilization has progressed due to their improvement and evolution into equally useful forms of technology.

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